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Wireless Alliance for Testing Experiment and Research (WALTER)

Experts workshop

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walter

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1. Executive Summary

The purpose of this document is to describe the WALTER experts workshop and related results and findings. The workshop was conducted in Ispra, Varese, Italy from the 2^{nd} to the 3^{rd} of July 2008 at the European Commission JRC facilities.

The purpose of WALTER workshop was to present and discuss the current regulatory, standardization and research status of UltraWideBand (UWB) technology with special focus on the definition of requirements, methodologies and tools for UWB measurements and testing.

The workshop was organized as part of the FP7 WALTER project (see 3 for a description of the WALTER project).

The WALTER workshop had the following main objectives:

- Identify the main regulatory and standardization challenges for the adoption of UWB in Europe and the world. Support the identification and resolution of conflicting requirements.
- Identify the main challenges in the UWB testing and measurements. Describe how the current industrial and research activity could support the resolution of these challenges.
- Discuss the future developments like UWB at 60 GHz and innovative interference and mitigation techniques including Detect And Avoid (DAA).

A number of international experts in the UltraWideBand field have been invited to participate to this workshop, to encourage bi-directional communication: in one direction to disseminate the information on WALTER project and its activities, in the other direction to collect the input and feedback on the regulatory and standardization work, industrial activity and research studies.

The WALTER workshop produced important results for the Joint Research Centre including a stronger relationship with ETSI and WiMedia standardization bodies, an improved understanding of the challenges in UWB testing and suggestions to address these challenges.

One of the key findings of the WALTER workshop was that new mitigation techniques like DAA must be improved and applied both at the standardization and regulatory levels to promote UWB technology in Europe and the world.

2. Acronyms

Acronym	Defined as
3G	Third-Generation (cell-phone technology)
API	Application Programming Interface
BTS	Base Transceiver Station
BWA	Broadband Wireless Access
CDMA	Code Division Multiple Access
DAA	Detect And Avoid
DS-OFDM	Direct Sequence - Orthogonal Frequency Division Multiplexing
DSRC	Dedicated Short-Range Communications
EC	European Commission
ECMA	European Computer Manufacturers Association
EESS	Earth Exploration Satellite Service
EFT	Environment Field Tests
EG	ETSI Guide
EMC	Electromagnetic Compatibility
EIRP	Equivalent Isotropically Radiated Power
EMF	Electromagnetic Field
ES	Electrical Safety
ETSI	European Standard Telecommunication Institute
EU	European Union
EUT	Equipment Under Test
FCC	Federal Communications Commission
FS	Forward Scatter
GPRS	General Packet Radio Service
GSM	Global System for Mobile communications
IEEE	Institute of Electrical and Electronics Engineers
ISO	International Organization for Standardization
IUT	Implementation Under Test
LOS	Line Of Sight
MAC	Medium Access Control

MAPS	Multi-Axis Positioning System
MMI	Man-Machine Interface
MoT	Means of Testing
NLOS	Non-Line Of Sight
OSI	Open System Interconnection
OTA	Over The Air
PAL	Protocol Adaptation Layer
PSA	Power Spectrum Analyzer
QE	Qualified Equipment
RAS	Radar Absorbent Structure
RE	Radiated Emissions
RPT	Radiated Performance Testing
RX	Reception
SDR	Software Defined Radio
SPC	Spectrum and Power Characteristics
STF	Special Task Force
SUT	System Under Test
TIS	Total Isotropic Sensitivity
TP	Test Purpose
TRP	Total Radiated Power
TX	Transmission
UWB	Ultra Wideband
WPAN	Wireless Personal Area Network
WRAN	Wireless Regional Area Network

3. WALTER project

The project Walter is a collaborative research project of FP7 (DG Infso). Started in 2008, for a period of 2 years, it includes 8 partners from Europe, Israel and China.
The partners are from the industrial world (AT4 wireless, CSR, Wisair, Copsey Telecommunications Ltd), research institutes (Joint Research Centre) and standardization bodies (ETSI, TMC).

This project aims to develop the methodology and technology needed for measurement, calibration, and testing of broadband radio signals like UWB.
Ultra Wide Band (UWB) is a very promising technology for the broadband transmission of data. Conventional wirelesses communication systems like GSM and UMTS use a narrow portion of the radio spectrum to transmit and receive voice and data.
UWB uses instead a large portion of the radio spectrum. Signal is defined as an ultra wideband if exceeds the lesser of 500 MHz or 20% of the center frequency signal bandwidth.
The current radio spectrum occupation of UWB in many countries around the world is from 3.1 GHz to 10.6 GHz. The risk of UWB is to create interference to existing wireless communication systems or localization services.

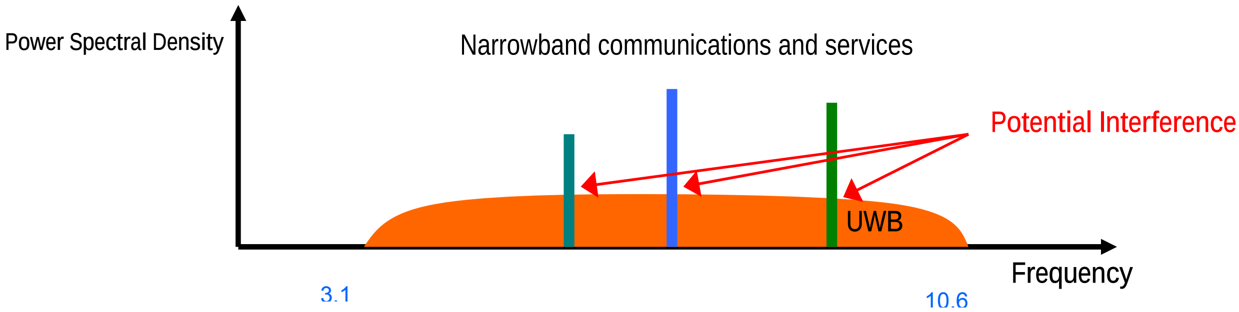


Figure 1 Spectrum Occupancy

To avoid interference, the UWB signal is constrained by regulations to very low emission power levels (between 41 dBm/MHz and 90 dBm/MHz).

Countries in the world define UWB emission masks for the maximum allowed EIRP levels.
For example, the current EIRP emission mask for Europe is below:

Frequency range (GHz)	Maximum mean e.i.r.p. density (dBm/MHz)	Maximum peak e.i.r.p. density (dBm/50 MHz)
Below 1,6	− 90,0	− 50,0
1,6 to 3,4	− 85,0	− 45,0
3,4 to 3,8	− 85,0	− 45,0
3,8 to 4,2	− 70,0	− 30,0
4,2 to 4,8	− 41,3 *(until 31 December 2010)* − 70,0 *(beyond 31 December 2010)*	0,0 *(until 31 December 2010)* − 30,0 *(beyond 31 December 2010)*
4,8 to 6,0	− 70,0	− 30,0
6,0 to 8,5	− 41,3	0,0
8,5 to 10,6	− 65,0	− 25,0
Above 10,6	− 85,0	− 45,0

Figure 2 UWB EIRP mask for Europe

Already being standardized in the United States, and supported by the WiMedia Alliance, UWB will be the basis of future generations of Wireless Personal Area Networks (WPAN) including Bluetooth, USB and Firewire wireless.

In this international context, the purpose of the WALTER project is to increase the competitiveness of Europe in UWB and WPAN.

The European Telecommunications Standards Institute (ETSI) is producing harmonised standards to foster UWB adoption in Europe but Europe is still late compared to USA and others. If not corrected, such a situation could hinder the European innovation potential to develop new applications and services based on this extremely high capacity networks.

European requirements specifically for the operation of UWB devices are a limited set of those already in operation in other regions of the global market. This places further restrictions on placing UWB on the European market with different performance to those that can be freely acquired from the other regions.
To allow both conformance testing of products and applications against developing UWB standards, interoperability of UWB technology with other radio technologies and finally, emergence of new opportunities by supporting the researches in the field, a new ranged of European broadband wireless test-beds is required.

Furthermore, because of low emission power levels, high throughput and large radio spectrum occupancy, measurement and certification of UWB technology against standards is extremely challenging.

The WALTER project will address this need by developing a pan-European interconnected test bed.

The availability of a reliable broadband test environment is vital:

- To assist the consolidation of test procedures for ETSI harmonized standards on UWB communication devices in support of the EU Radio and Telecommunications Terminal Equipment (R&TTE) Directive.
- To assist future development of UWB Harmonized Standards including mitigation techniques and coexistence mechanisms with potential radio victim services.
- To ensure interoperability between UWB devices, between UWB and other emerging technologies, taking into account future development in the field of wireless technologies.

Such a test-bed should be flexible and reconfigurable to cater for the competing needs of the different entities involved in the process (Industry, Regulators, and Research).

The Test Bed will have to support the development for the provision of competent validated test facilities and test systems that will support other new emerging broadband radio technologies.

The following picture describes the overall plan of WALTER:

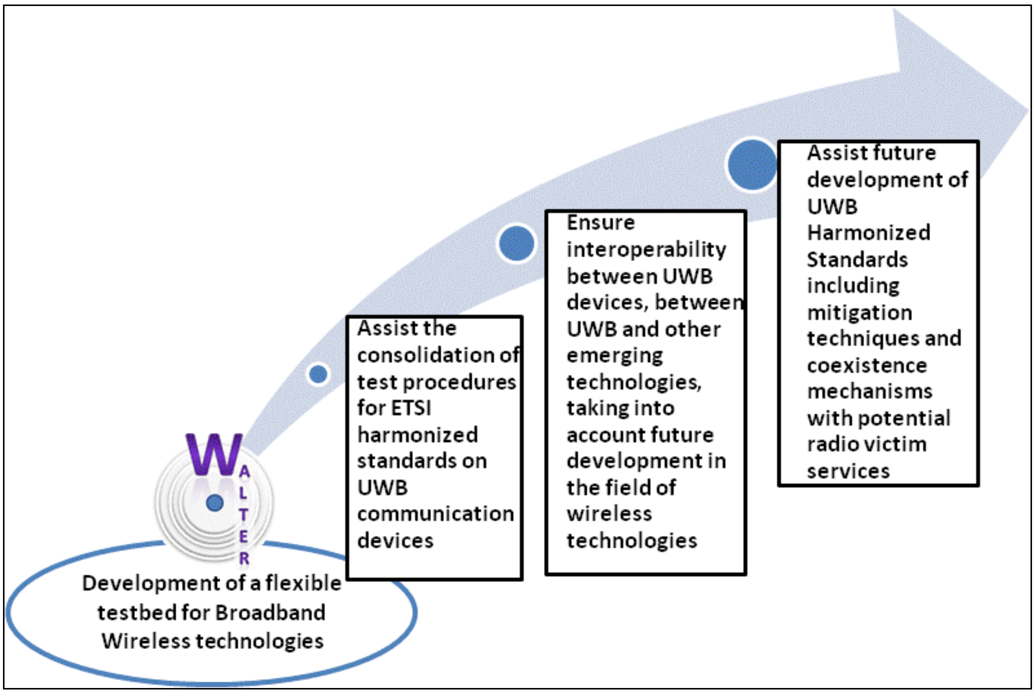


Figure 3 WALTER project objectives and overall plan.

4. Objectives, Agenda and Participants

4.1. Objectives

The objectives of this workshop were:

1. Present and discuss the current status of regulations on UWB communications around the world.
2. Present and discuss the current status on the standardization of UWB communications.
3. Discuss the research status of UWB interference and mitigation techniques including Detect And Avoid (DAA).
4. Discuss the technical challenges and approaches in the definition of test beds for measurements of UWB devices and evaluation of coexistence with other wireless systems.
5. Present the activities and work of WALTER and receive feedback from workshop participants.
6. Promote collaboration with other government, industry and research organizations, to benefit the work of WALTER project especially in the field of UWB testing and measurements.
7. Present the “status of art” on UWB measurements and testing by equipment vendors like Agilent, Tektronix and Rohde & Schwarz.

Two roundtables were dedicated to:

- Challenges on UWB measurements and testing. Low emission power, very large spectrum occupancy and very high data rate are difficult to measure using conventional test equipment, which are designed for narrowband conventional systems. Challenges and solutions have been proposed and discussed.
- Discussion on the research trends in UWB. Mitigation techniques like DAA are discussed and evaluated for their impact to regulations. Use of UWB in the 60 GHz band are also discussed for a number of applications including Intelligent Transportation Systems (ITS).

During the workshop, a questionnaire was presented to collect the opinion of the participants on a number of topics related to UWB measurements and testing.

4.2. Participants

The workshop gathered representatives from the main regulations, industry and research organizations including the partners of the WALTER project.

The list of participants in the WALTER project included the following categories:

- Professionals specialized in UWB regulatory, at an European, American and Asian level.
- Professionals contributing to other UWB FP projects like PULSERS, EUWB or UCELLS.
- Members of standardization organizations (WiMedia, ETSI, AT4Wireless).
- Academics specialized in UWB research. The following research areas were included: UWB signals interferences on Satellite DTV and GPS receivers (NIST), UWB propagation through antennas (University of Karlsruhe), or localization in UWB communication systems (UPC and CTTC).

- Vendors of UWB test equipments (Agilent, Rohde-Schwarz, Tektronix).

This is the list of the workshop participants:

Frank Greco	European Commission - DG INFSO - Spectrum Policy Unit	EU
Tan Siew Yoon	OFCOM Spectrum Policy Group	UK
Andy Gowans	OFCOM Spectrum Policy Group	UK
Emmanuel Fausserier	ANFR	FR
Thomas Weber	Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen	DE
Sven Zeisberg	GWT-TUD GmbH	DE
Dunger Hartmut	Bosch	DE
Roberto Aiello	Staccato Communications	USA
Luca De Nardis	UWB Group - University of Rome	IT
Jens Timmermann	Universität Karlsruhe (TH)	DE
Robert Llorente	Universidad Politecnica de Valencia	ES
Michael Cotton	NTIA	USA
Xiaochen Chen	Telecommunication Metrology Center of MIT	CHINA
Alan Dearlove	Copsey Communications	UK
Langer Adiel	WISAIR	IL
Friedbert Berens	ST Microelectronics	CH
Paolo Monzoni	Agilent	IT
Giulio Fabbro	Tektronix	IT
Franck Le Gall	Inno	FR
Sebastian Müller	ETSI	FR
Philippe Cousin	ETSI	FR
Dario Tarchi	EC JRC	EU
Joaquim Fortuny-Guasch	EC JRC	EU
Gianmarco Baldini	EC JRC	EU
Carlos Pérez Ruiz	AT4 Wireless	ES
Sylvia Reitz	Rohde&Schwarz	DE

Luca Colombo	Rohde&Schwarz	IT
Lino Conti	Rohde&Schwarz	IT
Magnus Sommansson	CSR	SE
Chris Simpson	CSR	UK
Abdur Rahim Biswas	CREATE-NET	IT
Radoslaw Piesiewicz	CREATE-NET	IT
Capela Miguel	ICP-ANACOM	P
Catoni Mauro	Rohde&Schwarz	IT
Cheroutre Alexandre	Inno	FR
Cleaver Joanne	Copsey Communications	UK
Droemmer Michael	Agilent	DE
Fuehrer Detlef	EC JRC	EU
Harrison Edward	Anritsu	UK
Navarro Monica	CTTC	ES
Pancera Elena	Universität Karlsruhe (TH)	DE
Rabbachin Alberto	University of Oulu	FL
Platt Matthew	Copsey Communications	UK
Sacchi Roberto	Agilent	IT
Zwick Thomas	Universität Karlsruhe (TH)	D
Sithamparanathan Kandeepan	CREATE-NET	AU
Soffientini Luigi	Tektronix	IT
Garcia Manuel	AT4 Wireless	ES

4.3. Workshop Agenda

The following was the agenda of the workshop:

Day 1:

9:00 - 9:30	Registration
9:30 - 10:30	**Presentation of WALTER project** Opening speech by Alois Sieber Head of SERAC Unit – IPSC – JRC WALTER Introduction (Philippe Cousin from ETSI) WALTER Project Structure and Management (Franck Le Gall from Inno AG) WALTER Technical View (Alan Dearlove from Copsey Communication)
10:30 - 10:45	Break – Distribution of WALTER findings to the participants and distribution of questionnaire on "What are the main challenges in UWB ?"
10:45 - 12:15	**UWB Regulatory status** European Regulatory Status on UWB. Presentation by Franck Greco (EC Spectrum Policy Group). “Generic regulation for UWB applications in Europe”. Presentation by Emmanuel Faussurier (ANFR). “UWB Detect and Avoid”. Presentation by Siew Yoon Tan (OFCOM UK). “UWB Regulatory Status in East Asia (China, Japan, Korea)”. Presentation by Xiaochen Chen (TMC).
12:15 - 13:00	**Coordination with other UWB projects** “PULSERS I/II and EUWB projects”. Presentation by Sven Zeisberg (GWT TUD). “Photonic ADC technology for spectrum measurement and wireless coexistence in UCELLS project”. Presentation of Roberto Llorente on UCELLS (University of Valencia).
13:00 - 14:00	Lunch
14:00 - 15:30	**Standardization activity and status** “Introduction to WiMedia”. Presentation by Roberto Aiello by Staccato Communications. "ETSI activities and achievements". Presentation by Thomas Weber (German Office of Bundesnetzagentur für Elektrizität, Gas, Telekommunikation, Post und Eisenbahnen). “About ETSI's interoperability events” by Sebastian Muller (ETSI). “WiMedia UWB technology. Introduction to the technology and certification”. Presentation by Carlos Pérez Ruiz (AT4 Wireless).
15:30 - 15:45	Break

15:45 - 17:30	**Research activity on UWB** “Measuring the Interference Effects of UWB Signals on Satellite DTV and GPS Receivers”. Presentation by Michael Cotton (NTIA – NIST, USA). “UWB flexible assets in radio, access, and network design”. Presentation by Luca De Nardis (Universita’ La Sapienza di Roma). “Ultra-Wideband Research at Centre for Wireless Communications (CWC)”. Presentation by Alberto Rabbachin (University of Oulu, Finland). “System and antenna aspects for UWB propagation”. Presentation by Jens Timmermann (Universität Karlsruhe). “Localization in UWB communication systems”. Presentation by Monica Navarro (UPC - Universitat Politècnica de Catalunya and CTTC - Centre Tecnològic de Telecomunicacions de Catalunya).
17:30 - 17:45	Collection of questionnaire results
17:45 - 18:15	Tour of JRC facilities (EMSL).
19:30 ->	Social Dinner at restaurant

Day 2:

9.30 - 10:00	**Presentation on "Challenges in UWB measurements and testing"**
10:00 - 11:30	**The view from the test equipment vendors** "WiMedia UWB PHY Simulation and Testing". Presentation by Michael Droemmer (Agilent). “R&S® AFQ100B - Tailored for UWB applications“. Presentation by Sylvia Reitz (Rohde-Schwarz). “Creating UWB Signals using Arbitrary Waveform Generators“. Presentation by Luigi Soffientini (Tektronix).
11:30 - 11:45	Coffee Break
11:45 - 12:00	Presentation of the Questionnaire results
12:00 - 13:00	**Round table on UWB Test Measurements challenges** What are the main challenges ? Analysis of WALTER findings and deliverables Discussion of relevant questionnaire results
13:00 - 14:00	Lunch
14:00 - 15:30	**Round Table on future UWB developments like UWB at 60 GHz and DAA** Current status of the research on these topics Current status of the standardization on these topics Potential applications. Cross-references of DAA with other project/activities (SDR/RRS/Coexistence/Spectrum Policy ?
15:30 - 16:00	Workshop Conclusions

5. Description of participants contribution

5.1. Presentation by Frank Greco (EC DG INFSO) on "UWB legal and regulatory process in Europe"

(* Disclaimer: the views expressed are those of the author and cannot be regarded as stating an official position of the European Commission)

Franck Greco presented the current legal and regulatory process for an EU single market in wireless services and devices, the generic Commission Decisions on UWB, future activities and supporting actions including DAA.

The objectives of EU Spectrum Policy are to support a coordinated approach to spectrum access in the EU and to remove spectrum 'bottlenecks' which could obstacle innovation in UWB or other wideband technologies.

From this point of view, UWB is a very promising technology but the requirements of spectrum efficiency and avoidance of harmful interference should be considered for all radio applications in EU.

The responsible European bodies for regulation were identified and described. They are European Union, Member states and CEPT.

Below is a picture of the relationship among these organizations:

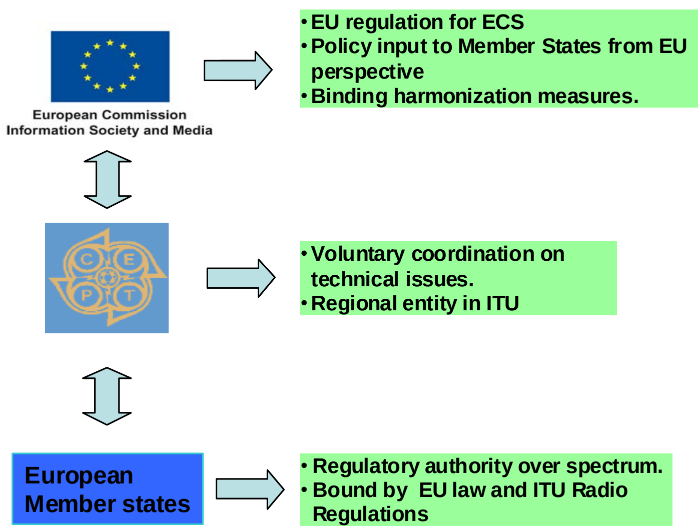


Figure 4 Relationship among European Commission regulatory bodies for UWB (source JRC).

The main commission decision was Commission Decision 2007/131/EC, which defines the Maximum e.i.r.p. densities (spectrum emission mask). Amendments to this Commission Decision are planned for Q1 2009 with the objective to relax restrictions or to introduce DAA mechanism.

5.2. Presentation by Siew Yoon Tan (OFCOM UK) on “UWB Detect and Avoid”

Tan Siew Yoon presented the current regulation status on Detect And Avoid (DAA) for UWB communications and the related requirements.

DAA is used in conjunction with protection zones, which are defined on the detected Uplink Power of victim communication systems, as for the following picture:

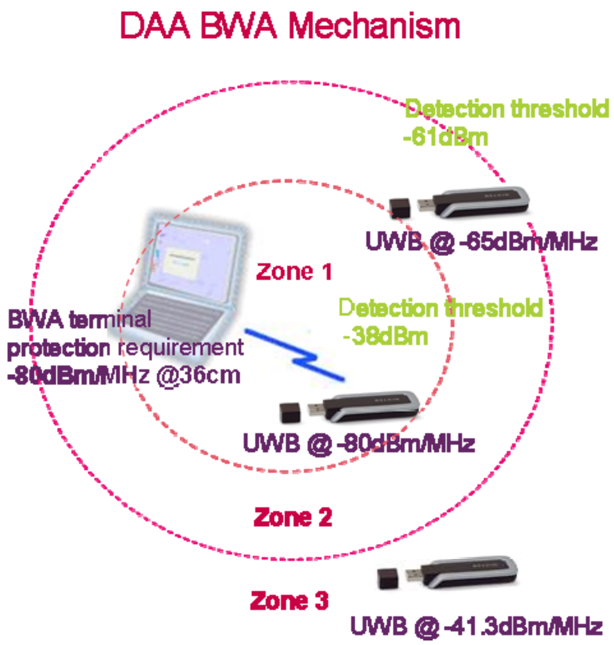


Figure 5 UWB DAA Protection zones (source OFCOM UK).

The presenter then described various challenges for the certification and related testing of DAA.

One main challenge is that DAA is victim specific and the technical requirements may need to be updated with technological changes. Another challenge is that detection probability and detect & avoid time may be difficult to determine for different service types. Minimum initial channel availability check time should also be agreed. The conclusion by the representative of OFCOM UK is that there is need to define test plans & procedures for different scenarios, different BWA service types and various radar signals and WALTER is the proper project for this purpose.

5.3. Presentation by Michael Cotton (ITS-NTIA/NIST) on “Measurement of interference effects of UWB signals”

The subject of the presentation was on measuring the interference effects of UWB signals.

The presented methodology was particularly interesting and it should be considered by WALTER project. The main elements are:

- Conducted, computer-controlled laboratory experiment to improve precision.
- Modular test bed allows for other systems to be evaluated more easily.
- Undesired signals are generated with Vector Signal Generator to remove dependence on manufacturers to provide signal sources.
- Objective performance metrics, e.g., BER and SER, quantify interference effects of the undesired signals.

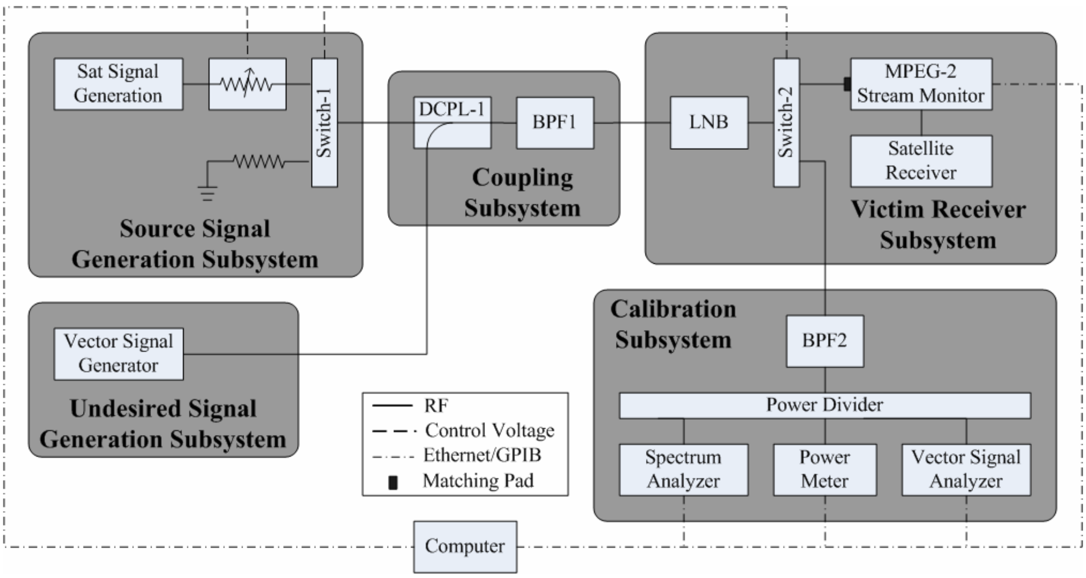


Figure 6 NTIA/NIST Methodology for UWB measurements (source ITS-NTIA).

The methodology was applied to measurements of interference of UWB emissions on C-Band Satellite DTV. Recently, NTIA has dedicated resources to developing Best Practices for Spectrum Engineering.
One outcome was the development of a quasi-analytic approach to assessing digital modulator performance in the presence of various undesired signals. A similar approach could be adopted in the WALTER project.

5.4. Presentation by Xiaochen Chen (TMC) on “UWB Regulatory Status in East Asia (China, Japan, Korea)”.

Xiaochen Chen presented the current regulatory status in East Asia and especially on DAA:

- In China DAA is being studied now (4 July 2008),
- In Japan DAA phase-in date will be revisited by MIC by end of this year. There is desire to open up 6-7.25 GHz band but no plan has been clearly defined yet.
- In Korea DAA is waived in 4.2~4.8 GHz until end of June 10th 2010. Current recommendations defined four options, but they could change to harmonize with global trend as needed.

There is desire to open up 6-7.2 GHz band (this will require a new work item) but no plan has been clearly defined yet.

An overview of the current regulatory situation in East Asia (China, Korea, Japan) is provided in the following picture:

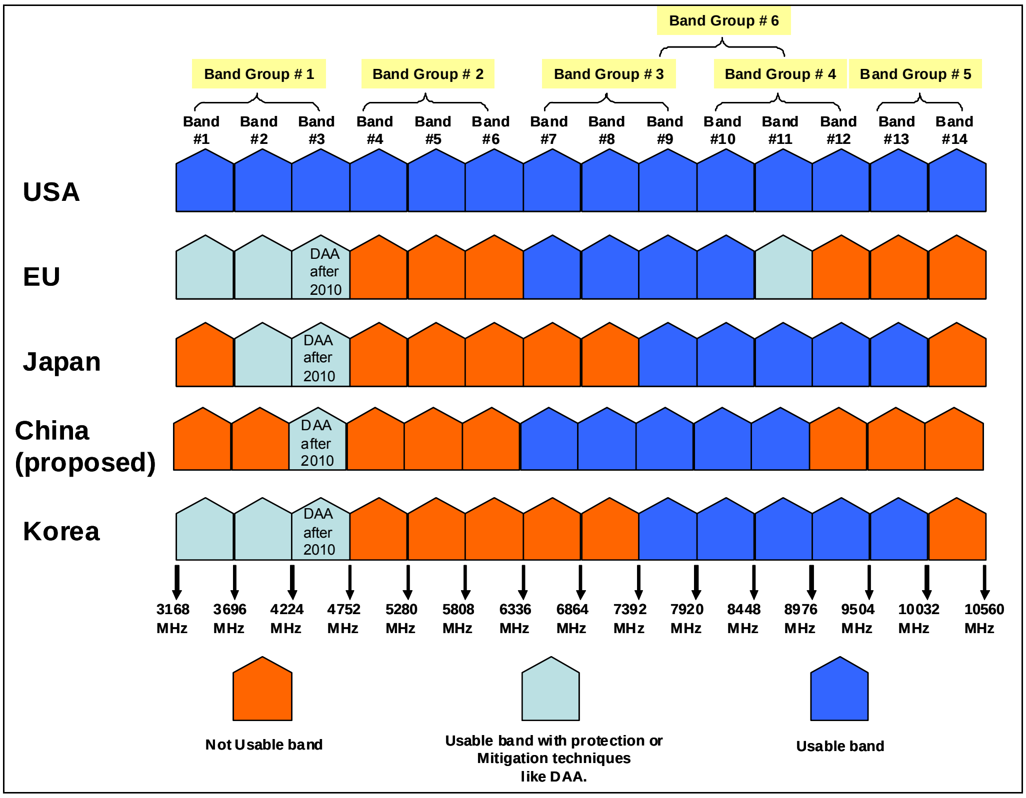


Figure 7 UWB regulatory overview in East Asia

5.5. Presentation by Emanuel Faussurier (ANFR) on “Generic regulation for Ultra-Wideband (UWB) applications in Europe”.

Emanuel Faussurier presented the generic regulation for Ultra-Wideband (UWB) applications in Europe.

A typical UWB coexistence scenario includes indoor and outdoor victim receivers. In indoor victim receiver scarios, mobile terminals (GSM, IMT-2000…), RLANs, BWA, T-DAB/DVB-T are used to produce interferences. In outdoor victim scenarios FS, FSS, EESS, Radio Astronomy are used.

The main regulatory EC decisions are ECC/DEC/(06)04 and ECC/DEC/(06)12. Faussurier described mitigation techniques like Low Duty Cycle (LDC) and DAA (Detect And Avoid).

DAA technical parameters alone do not ensure the protection of radio services by themselves.

This has to be completed with adequate DAA measurement procedures, which can be then incorporate in related ETSI standards.

5.6. Presentation by Thomas Weber (BNETZA) on “UWB Standardization Activities & Achievements in ETSI”.

Thomas Weber described the current activities and documents produced by ETSI:

- The generic Harmonized European Standard for UWB Communications (ETSI EN 302 065) has been published in February 2008. It includes the frequency ranges 3.1 – 4.8 GHz and 6 – 8.5 GHz as well as specific provisions for equipment using Low Duty Cycle (LDC) or for implementation in road or rail vehicles. Fixed outdoor installations are currently excluded.
- ETSI TS 102 754 has been published in June 2008. It includes the Detect-And-Avoid specifications (DAA) for UWB in 3.1 to 4.8 GHz and 8.5 to 9 GHz for the protection of Broadband Wireless Access (BWA) and radars. DAA as well as additional LDC provisions will be added in a revision of EN 302 065 before the end of 2008. Once the DAA mechanism has been validated, it will be a generic mechanism for the protection of a variety of radio services (radars, BWA, IMT, etc.)

There are a number of challenges in standardization. The main one is that UWB devices must support different emission masks around the world and this make the standardization process more complicated.

Standardization effort is also more complicated by the various applications of UWB like UWB onboard aircraft or outdoor.

The next step is the preparation of a Technical Report on Electromagnetic compatibility and Radio spectrum Matters (ERM); Short Range Devices (SRD) using Ultra Wide Band (UWB). The purpose of the document is to summarize the available information about the main types of transmission characteristics used by UWB devices (signal and modulation) including the related measurement methods with the corresponding parameters and principles for Power Spectral Density and Peak power definition and limitation.

The theoretical studies shall be completed by practical measurements.

An overview of the current standardization effort for UWB in sensor applications is presented in the following picture:

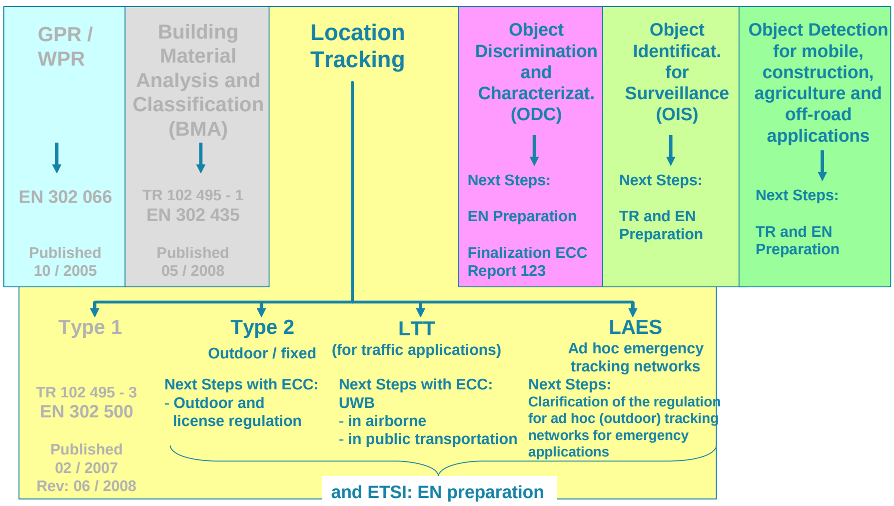


Figure 8 Standardization status of UWB in sensor applications (source ETSI)

5.7. Presentation by Sven Zeisberg (GWT-TUD) on "PULSERS and EUWB projects".

EUWB and PULSERS II is build on the expertise and work produced by previous projects in UWB including like PULSERS I, UCAN, ULTRAWAVES and so on.

The PULSERS II project produced a number of outstanding contributions to UWB research and measurements with important technical support to standardization and regulation. Measurements campaigns were conducted at the JRC as well (see reference [1] for a description of the PULSERS project).

These contributions included DAA definition, applications of UWB for rail and road vehicles and radar coexistence. PULSERS II provided support to the work of ETSI TG 31a and ETSI TG 31c.

Sven presented the EUWB project, which is an industrial driven R&D consortium. The 21 consortium partners are focusing on the integration and application of advanced Ultra-Wideband Radio Technology in major industrial sectors such us Consumer Equipment, Transportation, Automotive and Cellular Networks.

Application of EUWB are especially on air transportation and car transportation.

From the technological point of view, EUWB will also focus on interoperability with other fixed/wireless systems.

5.8. Presentation by Roberto Llorente (University of Valencia) on "Photonic ADC technology for spectrum measurement and wireless coexistence in UCELLS project".

Roberto Llorente presented the UCELLS project, which has the purpose of bringing cellular capabilities to UWB.

A number of application scenarios were defined including office and home. In these scenarios, UWB cellular capabilities are only possible with spectrum monitoring by a set of UWB sensors in order to guarantee that no interference is produced over other wireless services.

Below is a description of the possible application scenarios for UWB:

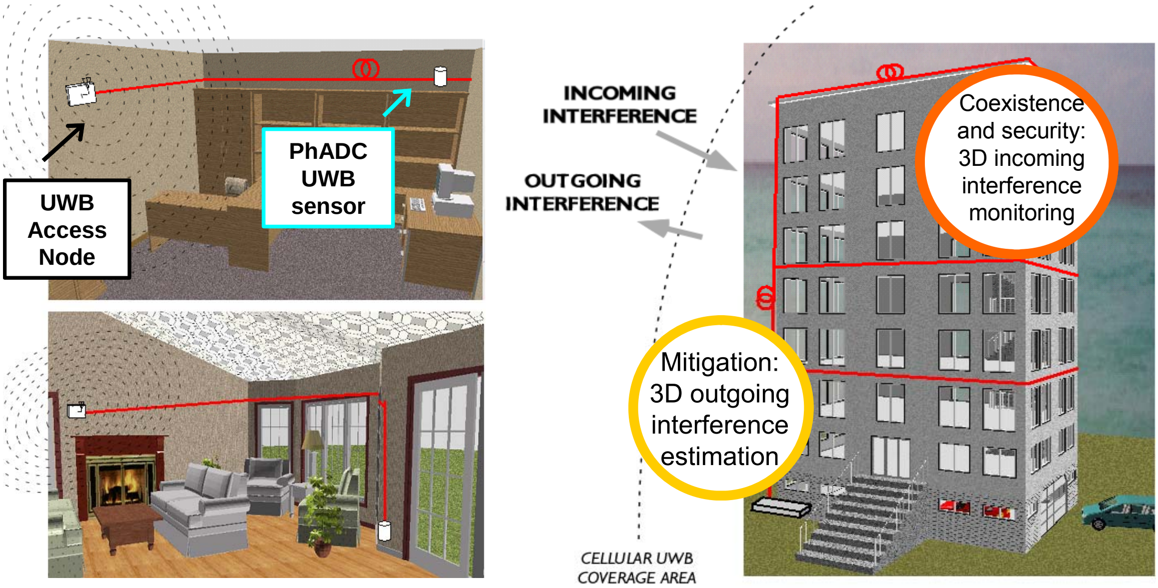


Figure 9 UWB application scenarios (from UCELLS FP7 project, reference [2])

The requirements for UWB spectrum monitoring are so high, that few technologies are viable to this effect. One of this is Photonic-ADC, which is used in the UCELLS project.

UCELLS is conducting measurement campaigns to ensure that cellular capabilities are implemented correctly and there is not interference with existing wireless systems.

5.9. Presentation by Roberto Aiello (Staccato Communications) on "WiMedia Alliance organization".

Roberto Aiello described the WiMedia Alliance, which is the current largest standardization body for UWB standardization in the world.

The WiMedia Alliance, a 350+ member global nonprofit organization, defines, certifies and supports enabling wireless technology for multimedia applications. Proven by its selection for Wireless USB and next generation Bluetooth, WiMedia UWB technology represents the next evolution of wireless freedom and convenience (from [3]).

WiMedia has already defined a number of technical documents and standards. Roberto presented also the overall architecture and the relationship to other standards.

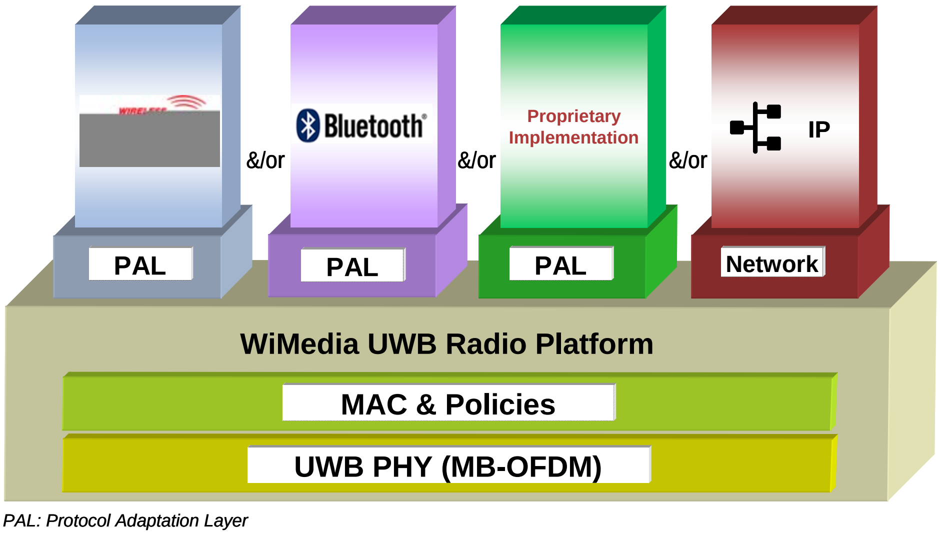


Figure 10 WiMedia overall architecture (from WiMedia)

The main challenge for WiMedia is the different regulations for emissions masks, which oblige the manufacturers to introduce more complexity in the UWB devices.

Roberto presented also a number of applications including wireless replacement, wireless docking and video on the go. By 2010, the plan is to increase the data rate, implement low power for mobile applications and implement spectrum enhancements like DAA.

5.10. Presentation by Sebastian Muller (ETSI) on "ETSI's Interoperability Events".

Sebastian Muller presented interoperability events in ETSI, which are organized to test devices produced by different companies.

The interoperability events have a number of features:

- It is system testing.
- Tests a complete device or a collection of devices.
- Shows that two (or more) devices interoperate.
- Interoperability testing looks at end-to end functionality.

The main reason for interoperability testing is because a device may be conformant to a standard but it may not be fully interoperable with other devices based on the same standard. The reason may be that the standard is not complete or they may be faults in the implementation of the device or the standard itself.

Conformance and Interoperability Testing are complementary; they are both needed to achieve interoperability of the devices.

Interoperability testing may have limitations:

- Cannot explicitly test error behaviour or unusual scenarios.
  Invalid conditions may need to be forced
  (lack of controllability).
- Has limited coverage (does not fully exercise the device).
  Difficult to automate, tests use more time to be prepared than executed.
- Does not prove 100% interoperability with other implementations with which no testing has been done: ‘A’ may interoperate with ‘B‘ and ‘B’ may interoperate with ‘C’. But it doesn’t necessarily follow that ‘A’ will interoperate with ‘C’.

Notwithstanding such limitations, interoperability events, have provided useful feedback to the standardization process, have accelerated time to market via quick product debugging, reduce deployment costs and allows networking with the market key players.

5.11. Presentation by Carlos Pérez Ruiz (AT4 Wireless) on “WiMedia UWB technology. Introduction to the technology and certification”.

Carlos Perez Ruiz presented WiMedia Alliance organization and approach for testing. WiMedia has produced two documents: WiMedia PHY Compliance and Interoperability Test Specification” Version 1.2. December, 2007 and WiMedia Platform Test Specification” Release 1.1. March, 2007.

WiMedia PHY test specification describes test cases for the transmitter side and for the receiver side. PHY test specification document provides the test requirements and test descriptions for WiMedia PHY testing.

WiMedia Platform Testing is relevant for anyone implementing the WiMedia MAC protocol:

- The test descriptions focus on performing testing on end products (not discrete MAC implementations).
- This test specification focuses on: beacon protocol, synchronization, interference mitigation, bandwidth sharing, etc.

WiMedia also defined the Certification process, which is composed by two parts:

Current WiMedia Certification Program is comprised of two parts:

- The first is a compliance and interoperability process that tests and “registers” Physical Layer implementations (PHYs) based on the WiMedia Alliance’s PHY test specification.
- Once a PHY is registered, the program’s second part, WiMedia Platform Certification, supports these eligible PHYs for use in a UWB platform that can be submitted for certification.

5.12. Presentation by Alberto Rabbachin (CWC Oulu, Finland) on “WiMedia UWB technology. Introduction to the technology and certification”.

Alberto Rabbachin presented the activity of the Centre for Wireless Communication (CWC) in Finland in UWB.

CWC works on different types of UWB technology:

- High data rate impulse-radio
- Low data-rate impulse-radio with location & tracking
- High rate multi-band OFDM (WiMedia)

The main fields of expertise are on theoretical PHY and MAC research, Cross-layer design and capacity studies, applied channel measurements, interference measurements, positioning algorithm, and ASIC development.

CWC has done extensive research and measurement on coexistence of UWB with other wireless devices like UMTS or WLAN. Aggregated interference has been investigated in a number of spatial configurations.

Future research studies are:

- Aggregate interference measurement campaign to validate and improve the statistical models and interference generated by several spatially scattered IR-UWB transmitters
- Coexistence of heterogeneous and uncoordinated networks. Analysis in realistic conditions, cross-layer analysis and MAC procedures to improve the co-existence.

5.13. Presentation by Luca De Nardis (University of Rome) on “UWB flexible assets in radio, access, and network design”.

Luca De Nardis presented the current research activities on UWB in the University of Rome.

A main research area is on pulse shaping where UWB pulses are shaped to conform to the regulators UWB emissions masks. Various types of pulses and different modulation schemes can be used to adapt the resulting signal to the emission mask.

Another area of research is on self-organizing network of low-power, low cost and low rate IR-UWB devices (IEEE 802.15.4a like devices). Time Hopping (TH) coding is used for identifying users. Power control at the CNode is assumed for all uplink connections.

A third area of research is on IR UWB flexible MAC design. The UWB^2 protocol proposed a pure Aloha approach for UWB. For synchronization purposes $(UWB)^2$ foresees the presence of a synchronization trailer in each transmitted packet. The Aloha approach proposed by $(UWB)^2$ was adopted with large majority of votes within the IEEE 802.15.4a group.

5.14. Presentation by Jens Timmermann (Universität Karlsruhe) on "System and antenna aspects for UWB propagation".

The contribution starts with an introduction into the UWB research topics at the institute. The current topics are channel characterization (measurement and modelling), antenna development and characterization (multiband antennas, small antennas, impulse radiating antennas like Vivaldi, slot, horn and monocone antennas] as well as dual polarized antennas for localization applications). Antenna arrays have also been investigated, for example for beamforming in time domain by a Rotman lens. Furthermore, analogue filters for the European UWB regulation have been designed and measured. Concerning system aspects, another research topic is the complete description and modelling of an UWB impulse radio transmission link including effects from non-ideal hardware. The developed models are also used to investigate influence of Dirty RF on UWB imaging algorithms. Finally, compensation techniques are also investigated as well as the combination of UWB and MIMO.

The current presentation highlights three aspects: modelling of non-ideal impulse radio transmission, development of dual-polarized antennas and development of analogue filters fort he European UWB regulation.

Concerning the first topic, it is shown how oscillator jitter can suppress unwanted discrete spectral lines resulting from the pulse repetition frequency. Then, the effect of antennas on the system impulse response is shown. Antennas do not only distort the signal but also add delays. The channel is characterized by Ray Tracing simulations, and the signal is amplified by a non-linear LNA. To estimate the performance of the system, bit error rate simulations have been performed for several channels and several data rates. The results show that an increase of data rate leads to a shift in the BER-SNR plot that can be described by the processing gain. If the data rate is too high, inter symbol interference degrades the performance.

Concerning the development of dual-polarized antennas, the contribution shows a dual polarized Vivaldi antenna, that has good matching and decoupling, high gain, symmetrical beam and the same performance for both polarizations. Also in time domain, a high peak value can be observed as well as short ringing and a small FWHM value. Measured results are also shown for a dielectric rod antenna.

The last topic shows analogue filters fort he European UWB regulation.

First, the existing masks are compared (Europe, FCC, Korea, Singapore, Japan). Then, a realized Chebychev filter is presented that has a ripple level of only 0.1 dB. The group delay variation is below 0.5 ns.

5.15. Presentation by Monica Navarro (CTTC - Centre Tecnològic de Telecomunicacions de Catalunya) on "UWB localization".

Monica Navarro presented the research work of CTTC in the implementation of localization functionality using UWB technology. Localization is based on Frequency domain Time-of-Arrival estimation.

The model is based on the following components:

- Frequency domain TOA estimator.
- Array Processing for TOA and DOA estimation. Low complexity frequency domain approach for joint high resolution estimation of TOA and DOA

- Positioning and tracking. EKF including TOA and DOA measurements improves the accuracy of the positioning system resulting particularly beneficial in NLOS scenarios and allowing location with a single access point.

Monica Navarro presented also the design of the UWB test bed, which was used to evaluate the UWB system and functionality.

Important conclusions of the research were:

- Antenna arrays were used, where TOA and DOA are jointly estimated by a linear estimator from the computation of the power delay spectrum by means on an FFT calculation at each array element and applied them for position tracking applying the EKF.
- Providing the reference node with an antenna array improve the accuracy of the tracking position system, especially if they are in NLOS condition.

5.16. Presentation by Michael Droemmer (Agilent) on “WiMedia UWB PHY Simulation and Testing”.

Michael Droemmer by Agilent presented the technical challenges in design and measurements of UWB communications.

Agilent has developed a test and measurements equipment chain to generate reference signals and to evaluate them through software for signal analysis. The equipment chain includes signal generator, oscilloscope and spectrum analyzers.

The following suggestions were provided for WALTER project:

- 500MHz to multi-GHz is the minimum BW needed to capture and analyze UWB signals. This requires a high speed digitizer (component) or oscilloscope (system) to capture the UWB signal.
- Regulatory testing necessitates Spectrum Analyzer
- Powerful Signal Analysis SW, can aid radio optimization, analysis and verification of operation.

5.17. Presentation by Giulio Fabbro (Tektronix) on “Creating UWB signals using Tektronix equipment”.

Giulio Fabbro by Tektronix presented the equipment for UWB signal generation.

Two fundamentally different concepts exist to generate arbitrary waveforms:

- True Arbitrary Waveform Generator (True Arb)
- Direct Digital Synthesis (DDS)

AWG7000 is the main equipment by Tektronix for signal generation. A description of AWG7000 was presented including I–Q Signals & Quantization, IF Generation & Over-Sampling and IF Filter Test. AWG 7000 has also the capability to importing waveforms in various formats including MATLAB®, mathcad® and Excel®. Tektronix provides also a software tool called RFXpress, which is quite powerful for waveform creation.

5.18. Presentation by Sylvia Reitz (R&S) on the “AFQ100B UWB signal and I/Q modulation generator”.

Sylvia Reitz presented the AFQ100B to generate various wireless signals and MB-OFDMA UWB with a maximum bandwidth of 600 MHz. The AFQ100B has a very powerful graphical user interface to load waveforms or to change the waveforms or modulation parameters. The waveforms are ECMA-368 conformant. MAC Header can be activated and configured.

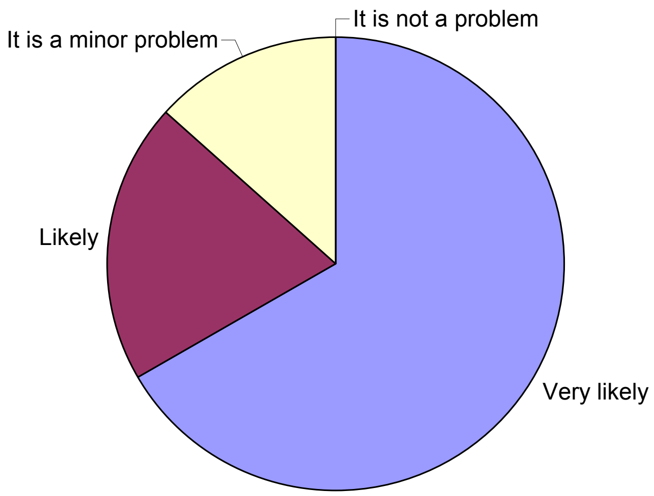
Finally AFQ100B can generate UWB pulse signals with bandwidth of 528 MHz (RF) and l Memory depth of 1 GSample.

6. Results of the Questionnaire

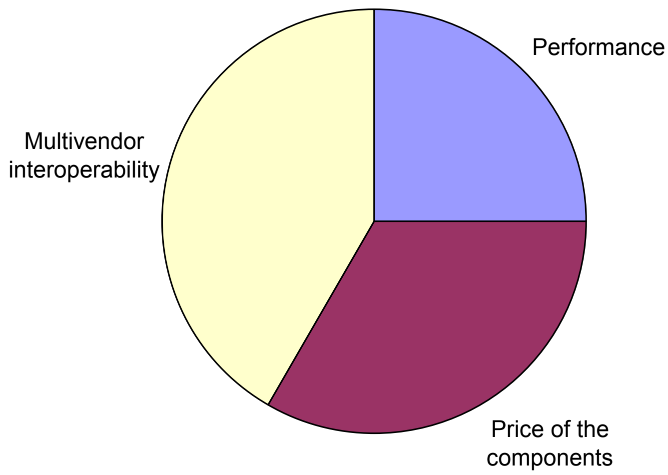
During the workshop, a questionnaire was distributed among the participants on a number of topics related to UWB research, industry, standardization and testing.

The following charts describe the questions and the correspondent answers.

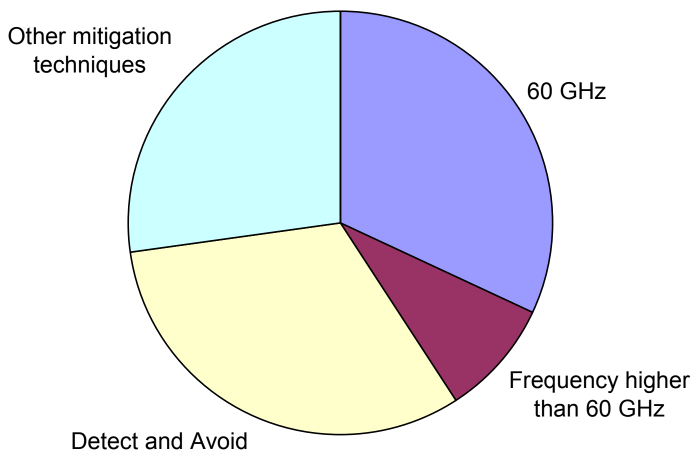
The presence of different spectrum regulatory masks across the world may create a problem to industry producers ?



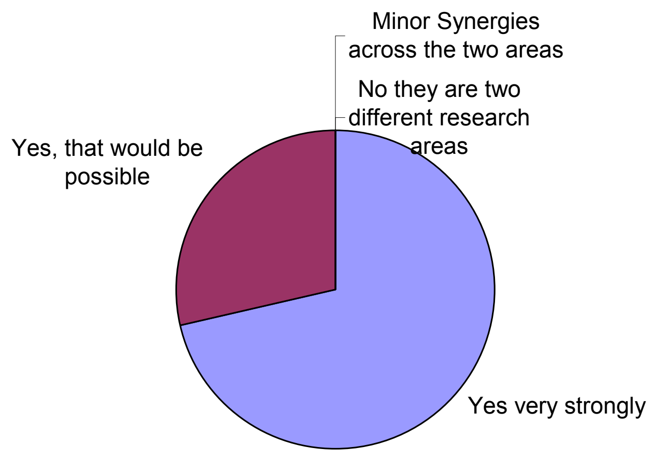
What are the most important concerns for UWB products ?



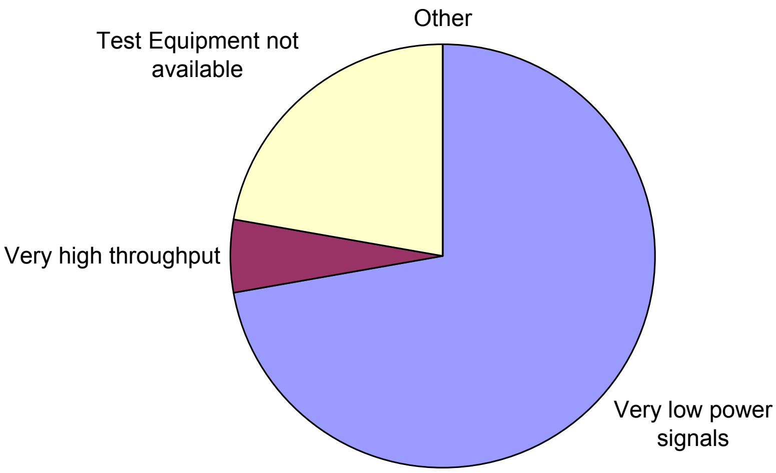
What are the next important areas in UWB research ?



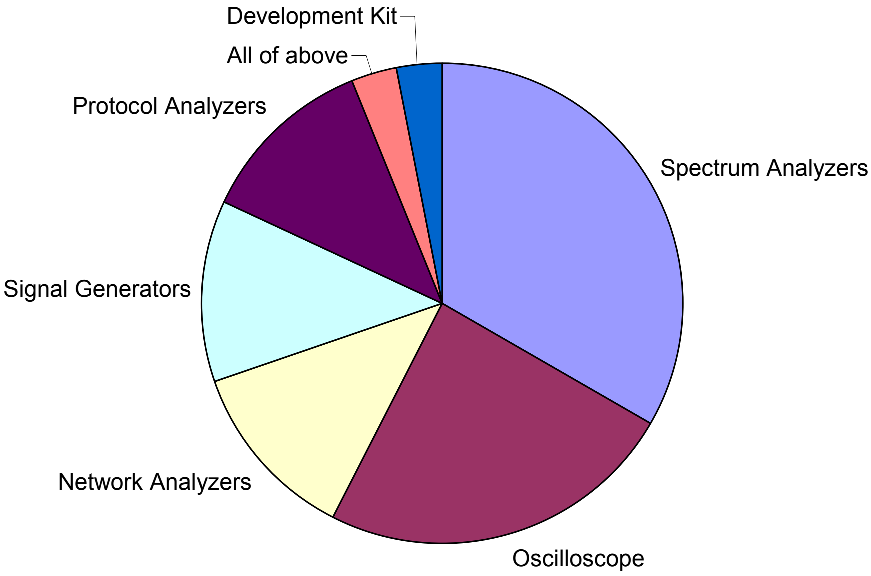
Do you think that it possible to create synergies between research in UWB mitigation techniques (like DAA) and research in Spectrum Management and Cognitive Radio ?



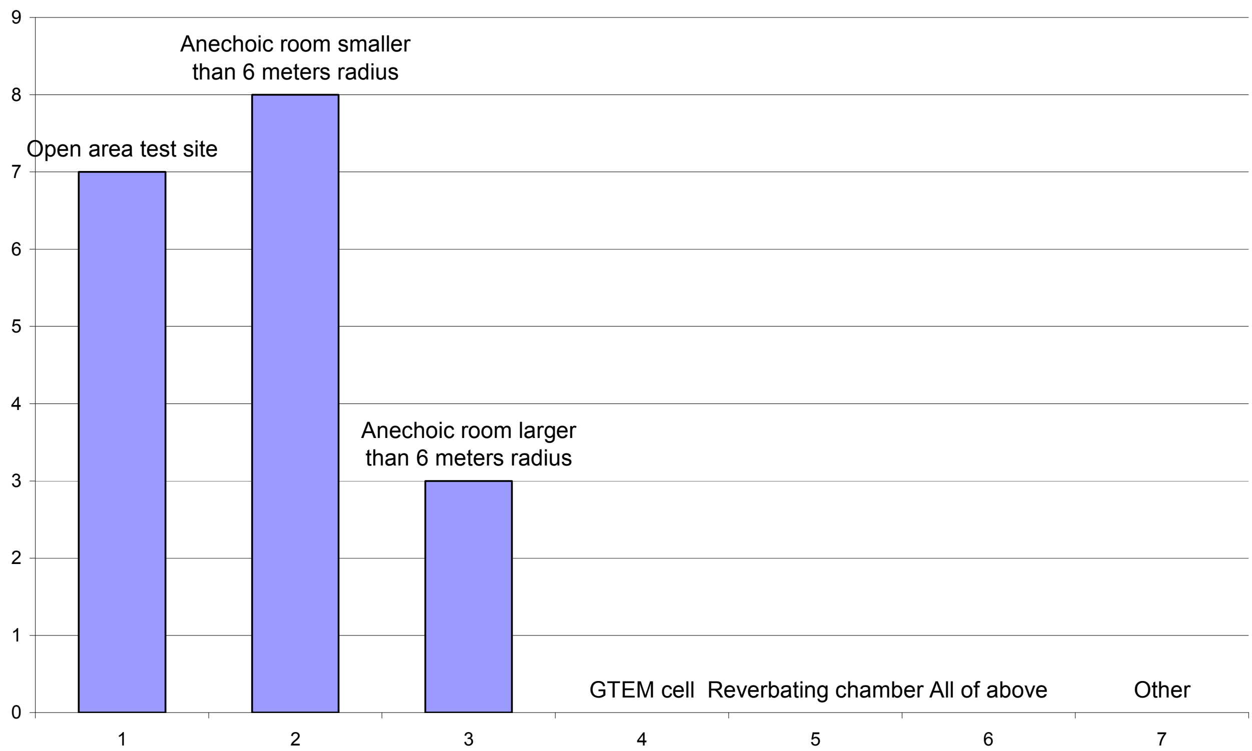
What are the biggest challenges in UWB measurements and testing ?



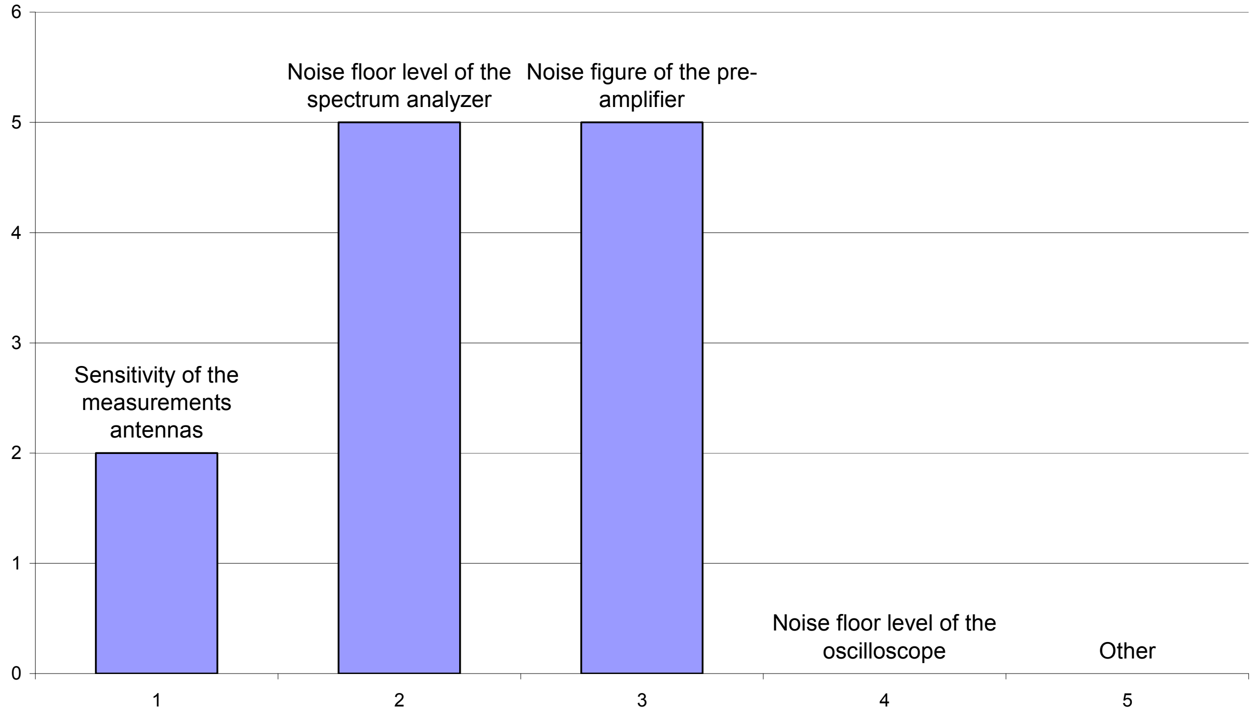
Which test equipment, do you use more frequently for UWB testing ?

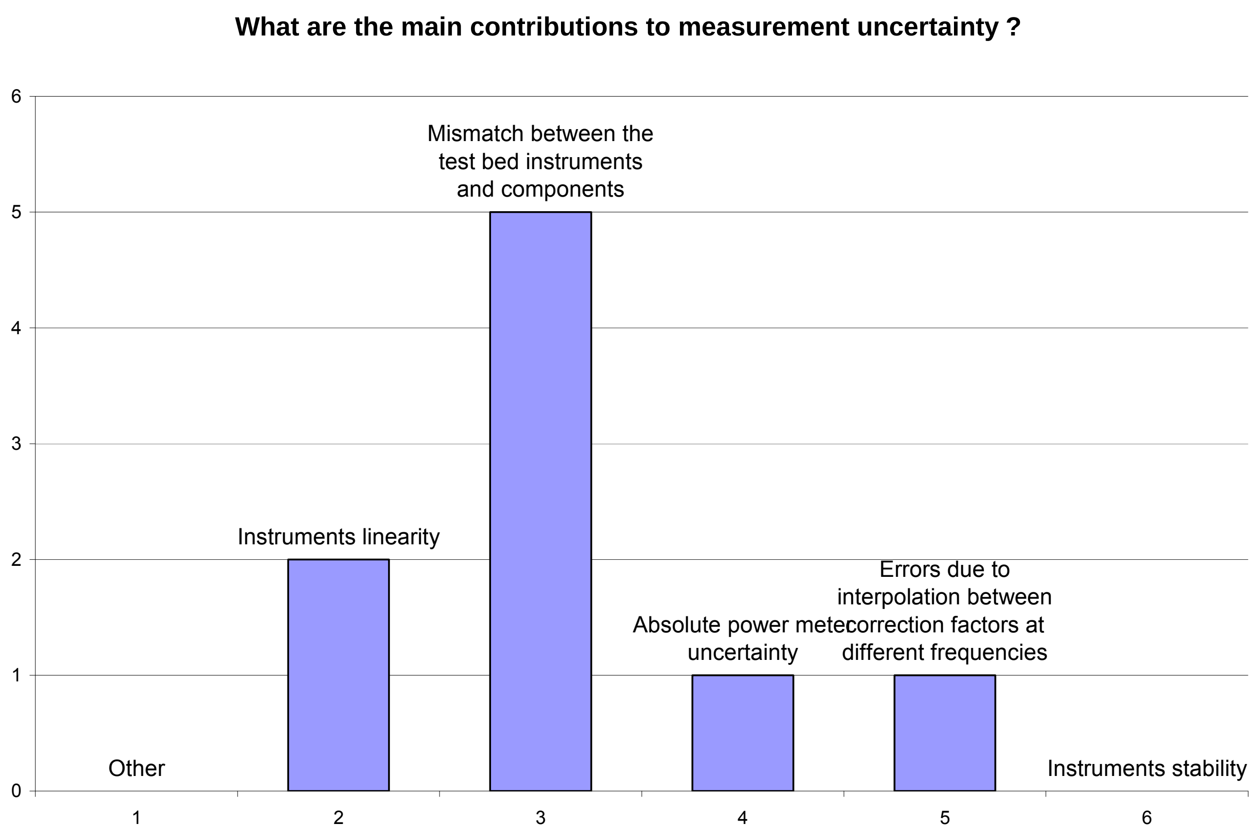


What type of measurements environments, do you use for UWB testing



Which elements of the testing environment, did you find more challenging for radiated measurements at low UWB power levels ?




What are the main contributions to measurement uncertainty ?
6
5
4
3
2
1
0
Mismatch between the test bed instruments and components
Instruments linearity
Errors due to interpolation between correction factors at different frequencies
Absolute power meter uncertainty
Other
Instruments stability
1
2
3
4
5
6

7. Round Table on UWB Test Measurements challenges

Because of its characteristics, UWB presents very difficult challenges from the measurement and certification point of view:

- A main challenge is represented by the the low EIRP levels, which can be around -90 dBm/MHz. This is near the noise floor level of many test equipment and it makes extremely difficult the detection of UWB signal.

  Few solutions were presented by WALTER participants. One solution is to limit the frequency window where the measurements are conducted. For example a spectrum analyzer can be configured to fetch signal only in a 1 MHz bandwidth or even smaller. In this case the noise figure is limited. The trade-off is that much more time is needed to conduct the measurement. All the samples must then be collected and correlated. Another solution is to decrease the thermal noise of the test equipment by dropping the temperature of the environment to very low temperature (around 20 K). In this case the noise floor is very low (can even go to -140 dBm) and UWB measurements can be taken more easily.

- Another challenge is the very large bandwidth of the UWB signal (around 500 MHz). Even simple power spectral density measurements can be difficult as regulations require a 50 MHz resolution bandwidth (RBW) that few spectrum analyzers support. An additional challenge is the use of time frequency codes (TFCs) that spread the UWB signal. A solution is (as in the previous case) to execute measurements with a smaller bandwidth and then correlate the measurements even if this introduces potential errors and longer time for measurement.

- During testing, UWB signals must also be generated using signal generators. This is also a critical challenge because many conventional test equipments are designed to generated narrowband signals. UWB signals require an enormous bandwidth capability. Depending on the UWB modulation to be generated, different signal generation approaches may be needed. Signals like TH-UWB and DS-UWB are typically generated entirely at base-band and require many Giga Hertz of base-band bandwidth. Other signals like MB-OFDM can instead up-converted to the appropriate RF band. Up-conversion methods require less base-band bandwidth, but add the complexity of an external up-converter or modulator.

- Testing a UWB receiver's interference sensitivity is another challenge. The large bandwidth of an UWB signals can cover a wide range of potential narrow band interference sources. Equipment vendors at the workshop said that they are working on providing solutions to this challenge by improving the capability and sensitivity of their equipment.

- WiMedia's MB-OFDM UWB modulation is complex and it quite challenging when the tester needs to characterize performance. UWB signals can be distorted by ultra wideband component characteristics. This is because amplitude or phase measurements may not be linear with such wide bandwidth. The increased processing capability of new test equipments may address this challenge.

8. Round Table on future UWB developments like UWB at 60 GHz and DAA

The participants agreed that the two main interesting areas from the research point of view are UWB at 60 GHz and mitigation techniques like DAA.

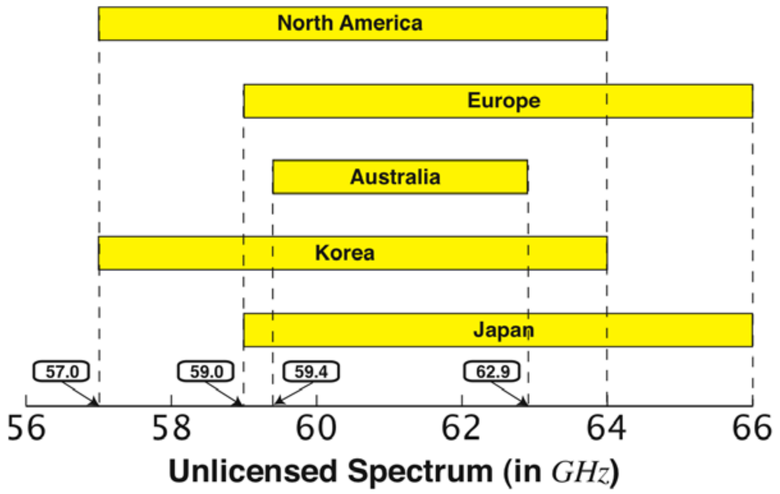


Figure 11 UWB at 60 GHz (from [4]).

As is evident in Figure 11 UWB at 60 GHz, the frequency range around 60 GHz is becoming increasingly popular. One of the reasons, besides the high data rates that can be achieved at this frequency, is the availability of unlicensed spectrum in many countries around the world.

There are various standardization bodies and industry groups active in defining new standards in this frequency band.

The IEEE 802.15.3 Task Group 3c (TG3c) which was formed in March 2005 is developing a millimeter-wave-based alternative physical layer (PHY) for the existing IEEE 802.15.3 Wireless Personal Area Network (WPAN) Standard 802.15.3-2003.

This mmWave WPAN will operate in the band including the 57-64 GHz unlicensed band defined by FCC 47 CFR 15.255.

WirelessHD, an industry alliance comprised of Intel, LG Electronics, Matsushita (Panasonic), NEC, Samsung, LTD, SiBeam, Sony and Toshiba released a wireless digital interface specification for HDAV transmission which works in the 60 GHz range, in January 2008. Two PHYs have been specified, a high-rate PHY (HRP), occupying 1.76 GHz of bandwidth and a low-rate PHY (LRP), occupying 92 MHz of spectrum. see [5] for futher details.

In March 2008, ECMA TC48 started working with the Wimedia Alliance on a standard for a 60 GHz PHY and MAC for short range unlicensed communications.

The IEEE 802.11 Study Group on Very High Throughput (VHT) works on technologies in the 5 GHz and 60 GHz bands; for very-high-speed wireless networks, such as audio/video transmission and access to networked storage.

Detect and avoid techniques mitigate interference potential by searching for wireless signals (narrowband and broadband) and then automatically switching the UWB device to another frequency or channel
to prevent any conflict. As such, ‘detect and avoid’ technology provides the capability to minimize interference to victim services and improve coexistence of UWB with other wireless communication systems.

DAA is considered by the workshop participants as a simple form or Cognitive Radio.
Cognitive Radio is defined as:
“Software radios are emerging as platforms for multiband multimode personal communications systems. Radio etiquette is the set of RF bands, air interfaces, protocols, and spatial and temporal patterns that moderate the use of the radio spectrum. Cognitive radio extends the software radio with radio-domain model-based reasoning about such etiquettes. Cognitive radio enhances the flexibility of personal services through a radio knowledge representation language.” Extracted from [6].

In this sense many workshop participants agreed that research groups should join their forces and found synergies in the research for DAA and Cognitive Radio.

DAA is currently investigated for its application to the regulatory domain, where it can used to relax the EIRP emission mask. The concept is that an UWB transmitter could increase the power if it does not ‘detect’ another communication service in the radio spectrum.

Cognitive Radio techniques in UWB are currently investigated in FP7 Integrated Project EUWB.

One important challenge in the testing and evaluation of DAA mitigation is to recreate a realistic environment to determine the impact of UWB on other wireless communication services.
The spatial configuration and architecture of the test bed is also of primary importance to evaluate DAA in the correct way.

9. Conclusions

There were a number of important outcomes from the WALTER project including:

1. WiMedia and ETSI representatives were present at the workshop. Various forms of collaborations were discussed during the workshop with the effect of strengthening the relationship between WiMedia and ETSI, with important benefits for the WALTER project.
2. The main challenges of UWB measurements were discussed and a number of ideas were proposed by the participants. A number of participants including OFCOM UK, NTIA/NIST, CTL, AT4 Wireless and JRC agreed to continue the collaboration and exchange of information on this topic. A number of new approach and technologies were discussed like fine tuning of the measurement bandwidth, combination of time domain and frequency measurements and other.
3. We established contact channels with equipment vendors to establish a bidirectional feedback. On one direction, equipment vendors will provide information on upcoming products or they shall provide support to WATER project. On the other direction, WALTER partners will provide feedback on the performance of the equipment and on the major needs for UWB testing, which can be useful for the prioritization in product development.
4. The presentation and feedback provided by the regulators and industry were important contributions for the definition of the WALTER deliverables. Research centres provided quite useful input on the testing and measurements of DAA technologies as they were the first to implement DAA in UWB emitter prototypes.

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Abstract

The purpose of this document is to describe the WALTER experts workshop and related results and findings.
The workshop was conducted in Ispra, Varese, Italy from the 2nd to the 3rd of July 2008 at the European Commission JRC facilities.

The purpose of WALTER workshop was to present and discuss the current regulatory, standardization and research status of UltraWideBand (UWB) technology with special focus on the definition of requirements, methodologies and tools for UWB measurements and testing.

The workshop was organized as part of the FP7 WALTER project (see 3 for a description of the WALTER project).

The WALTER workshop had the following main objectives:

- Identify the main regulatory and standardization challenges for the adoption of UWB in Europe and the world. Support the identification and resolution of conflicting requirements.
- Identify the main challenges in the UWB testing and measurements. Describe how the current industrial and research activity could support the resolution of these challenges.
- Discuss the future developments like UWB at 60 GHz and innovative interference and mitigation techniques including Detect And Avoid (DAA).

A number of international experts in the UltraWideBand field have been invited to participate to this workshop, to encourage bi-directional communication: in one direction to disseminate the information on WALTER project and its activities, in the other direction to collect the input and feedback on the regulatory and standardization work, industrial activity and research studies.

The WALTER workshop produced important results for the Joint Research Centre including a stronger relationship with ETSI and WiMedia standardization bodies, an improved understanding of the challenges in UWB testing and suggestions to address these challenges.
One of the key findings of the WALTER workshop was that new mitigation techniques like DAA must be improved and applied both at the standardization and regulatory levels to promote UWB technology in Europe and the world.

Mission of the JRC

The mission of the JRC is to provide customer-driven scientific and technical support for the conception, development, implementation and monitoring of EU policies. As a service of the European Commission, the JRC functions as a reference centre of science and technology for the Union. Close to the policy-making process, it serves the common interest of the Member States, while being independent of special interests, whether private or national.